Pollution Prevention at the Los Alamos National Laboratory
DX-2 PBX Operations

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Background

The mission of the Dynamic Experimentation Division (DX) is to develop and maintain a vital and competent capability in explosive technology and hydrodynamic, hydronuclear, and nuclear weapons testing. DX-2 is the group at the Los Alamos National Laboratory (Laboratory) concerned with all aspects of high explosives (HE) including:

- Chemistry, engineering, materials properties, and physics related to the synthesis; formulation, performance, and safety of explosives;
- Monitoring and surveillance of explosives in the nuclear stockpile;
- Unique applications of explosives; and
- Environmentally-conscience destruction/disposal of explosive and explosive devices.

In the near future, the process for making PBX high explosives will move to Laboratory Technical Area 9. This is part of the Laboratory's mission to enhance surveillance as part of the Nuclear Stockpile Stewardship program. Personnel assigned to the PBX process have decided to consider the most efficient and environmentally-sound PBX explosive production method before it moves to TA-9. The current PBX explosive manufacturing method is efficient, however, it generates some undesirable waste streams. The group decided to use the Green Zia systems approach to improve the current PBX explosive production process and to seek to eliminate a solvent in water waste stream. These process improvements are estimated to reduce waste volume from 11,000 kg to 5,500 kg with the total savings from $244.000 to $122.000. In addition, these improvements will reduce the water waste from 48 gallons of water to 4, 770 KG of water. In addition, they will improve the current process by making a few incremental changes and are planning to continue to reduce waste in the future by making more significant changes to their process. This will result in significant operational cost savings, provide more time to work on their mission by reducing waste management time, and improve the public's perception of DX-2.

This report documents Los Alamos National Laboratory's application of the Green Zia Tools as specified in Functional Area 3 (Managerial Accomplishments) of Section B, Part II-1, Appendix F of the DOE/University of California contract (1999). The Green Zia analyses were accomplished according to New Mexico Green Zia Environmental Excellence Award program guidance http://www.nmenv.state.nm.us/.

The Challenge

Production of PBX explosives requires the use of methyl ethyl ketone (MEK).

Acknowledgements

John Kramer	Dynamic Experimentation Division (DX-2)
Jim Stine	Dynamic Experimentation Division (DX-2)
Ray Flesner	Dynamic Experimentation Division (DX-2)
Robert B. Pojasek	Consultant, Pojasek and Associates
Dianne Wilburn	Environmental Stewardship Office (ESO)

This solvent contaminates the waste water creating a large volume of waste that is subject to regulation by the U.S. Environmental Protection Agency (US EPA) and the New Mexico Environment Department under the provisions of the Resource Conservation and Recovery Act (RCRA).

It is currently expensive to dispose of this regulated waste. However, the cost to DX-2 will increase in October 1999 when a LANL-wide waste generation fee is applied. In addition, since the waste stream contains traces of HE, it is extremely difficult to find a facility that will dispose of it. Production personnel are also constrained by Department of Energy (DOE) criteria recognizing the suitability of this solvent for this particular production process. This makes it difficult to propose a more environmentally-friendly solvent since it may not produce an explosive product that is acceptable to DOE specifications.

PBX production personnel decided to meet this challenge by applying the Green Zia systems approach to address these issues. This paper will explore how a team was formed and how this team used the following tools to address issues involved in the PBX process:

- Determining opportunities in the current process using process maps;
- Rank ordering of the opportunities to improve the process using Pareto analysis and activity-based costing;
- Determining the root cause of the selected opportunity using a cause and effect (fishbone) diagram;
- Posing a consensus problem statement for generating process alternatives;
- Generating process alternatives using a brainwriting tool;
- Selecting an alternative using bubble-up/bubble-down (forced pairs comparison); and
- Implementing the selected alternative with a formal action plan.

Green Zia PBX Team

A multi-disciplinary team was formed to address the improvement of the PBX explosive production process. Participants on this team included people familiar with the PBX production methods. The following individuals were members of this team:

- Jim Stine, HE Deputy Group Leader
- Alicia Hale, Team Facilitator
- Dianne Wilburn, Hazardous Waste Specialist
- John Kramer, HE Engineer
- Raymond Flesner, Team Leader
- Brian Thompson, Green Zia Specialist
- Bryan Carlson, Low Level Waste Specialist
- Carl Thornton, Communications Specialist
- D'Ann Bretzke, Construction Specialist.

This team met on several occasions to complete the work on this project.

Process Characterization

The team prepared process maps for the PBX explosive production process (see Figures 1 – 4). Figure 1 starts with a top-level process map ending with a breakdown of the top-level map into more specific maps (Figures 2-4). What is listed below is the top-level map for the DX-2 PBX

Slurry process. Figure 1 consists of six work steps: De-wet HMX, loading and weighing, distillation, filtering and drying, quality assurance check (QA), and storage of the product. The arrows at the top of the work steps are the resource inputs (such as energy), and the arrows at the bottom of the work steps are the material losses (such as Ethanol H2O). Usually, material uses and losses are portrayed during the breakdown of the top-level map, however, work steps 1 and 5 needs no further detail so the resource/material uses and losses are illustrated at the top-level map.

Figures 2 and 3 are detailed process maps of work steps 2.0, 3.0, and 4.0. These maps illustrate how the PBX HE is produced and what materials are used (such as MEK) and lost (such as liquid solvent) during the production process. It is beneficial to visually assess the PBX Slurry process because it provides opportunities for the team to view their environment, health and safety issues. Furthermore, once the team decides on a solution, they can return to the maps and determine which work steps where they want to target for implementing the solution. For example, the DX-2 team wanted to reduce the amount of water used when creating the PBX batch. The team used the maps to determine that they could reduce their water usage in work steps 4.2 (see Figure 3) by using less water when rinsing the PBX batch.

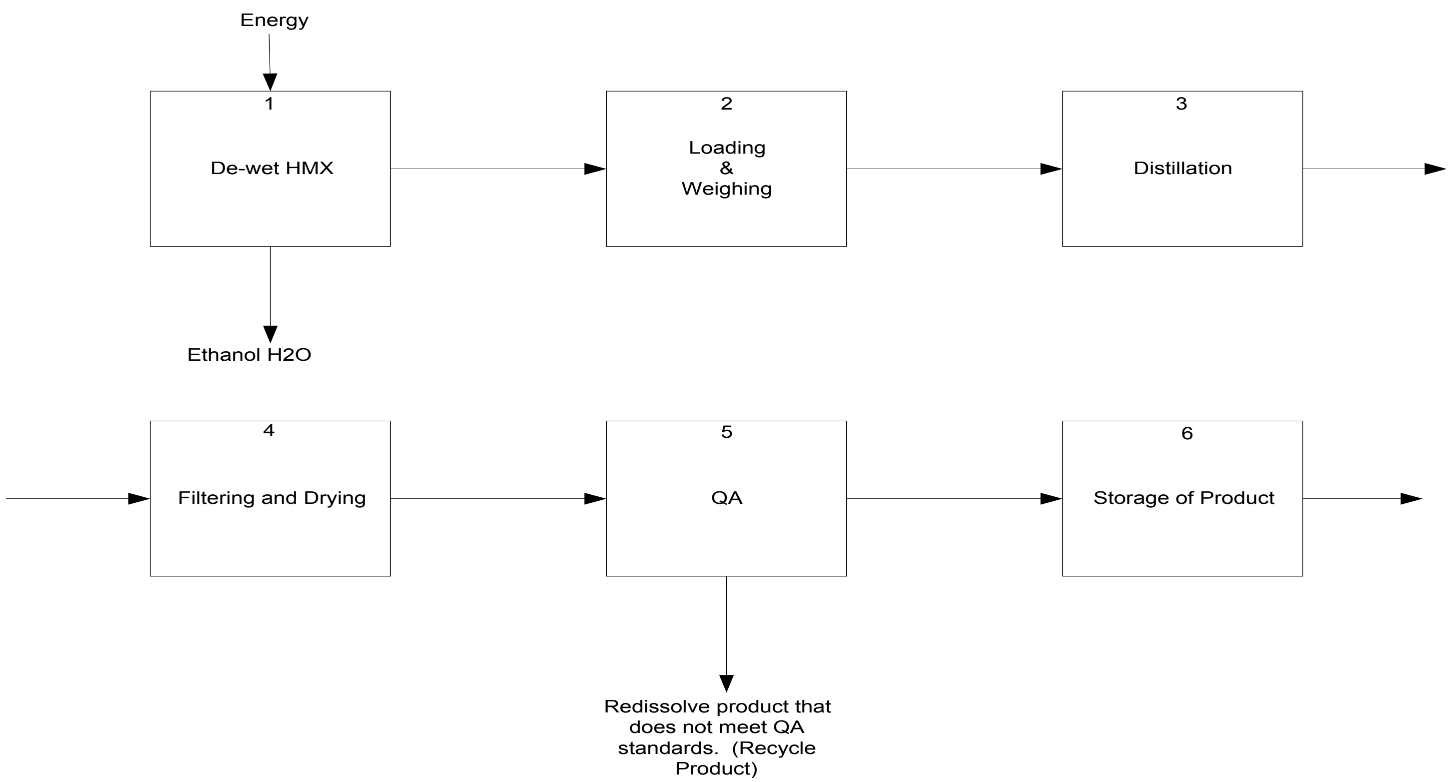

Figure 1. Top Level Map Illustrating PBX Slurry Process

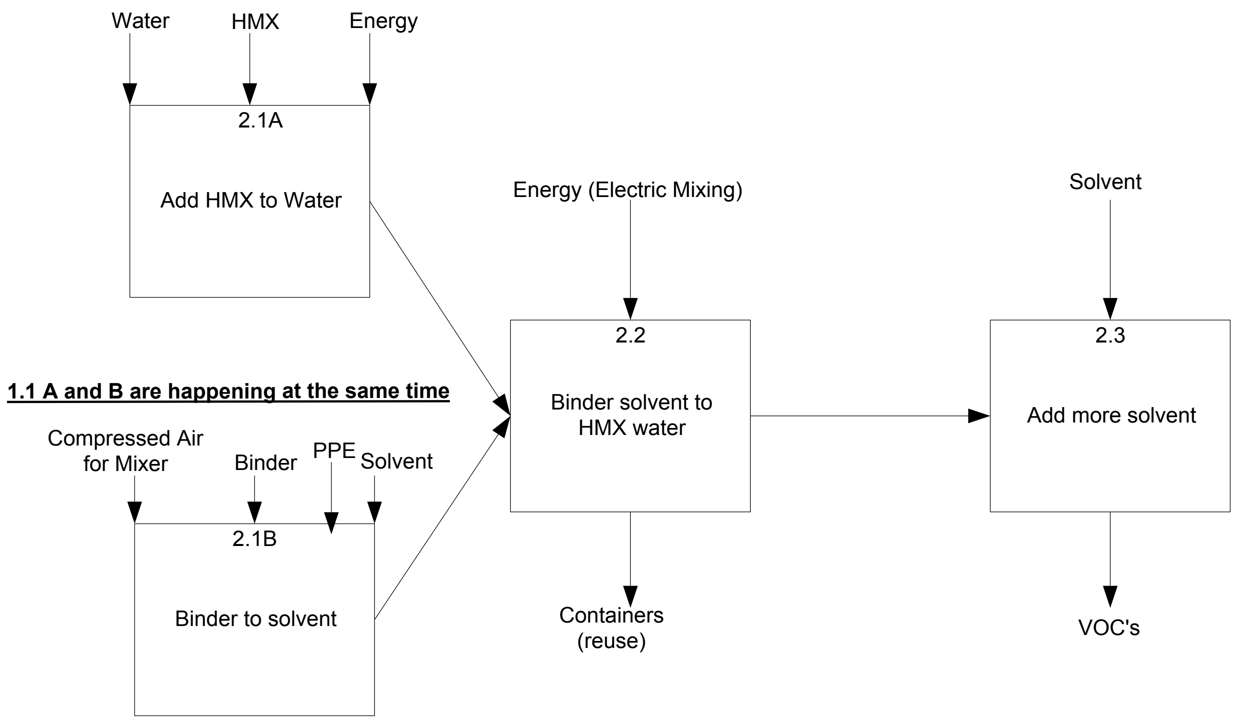

Figure 2. Detailed Process Map Illustrating Work Step 2.0

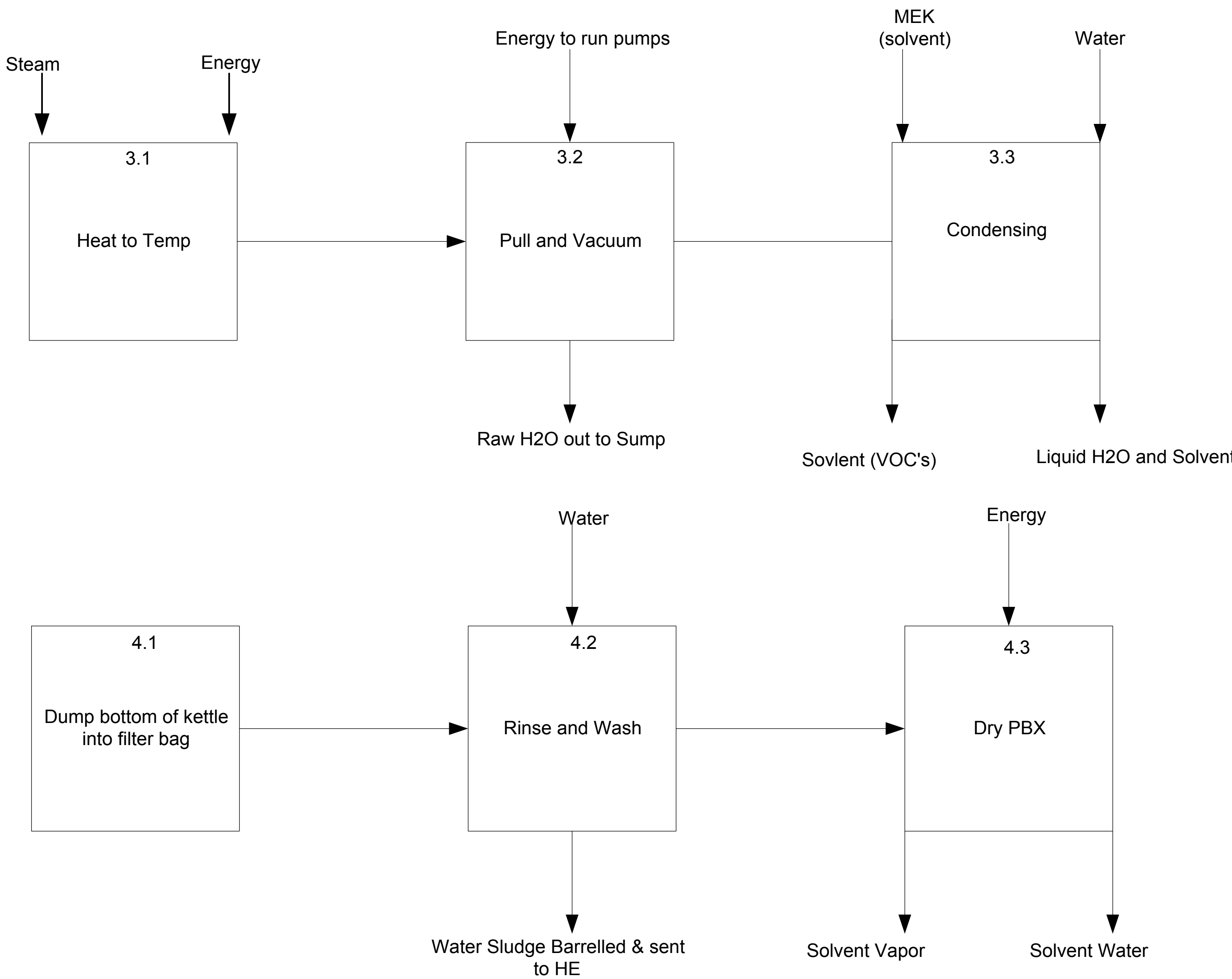

Figure 3. Detailed Process Maps Illustrating Work Steps 3.0 & 4.0

All of these maps represent the main PBX Slurry process, however, there are ancillary and intermittent operations which are smaller operations that assist the main operation. For example, barreling up the liquid solvent waste at the end of the PBX slurry process is considered an ancillary operation (Figure 4) because it is a smaller operation that assists the main operation (Figure 1) of storing the product (work step 6.0). Ancillary and intermittent operations are important to capture because some of the most significant material losses can occur during an ancillary/intermittent operation.

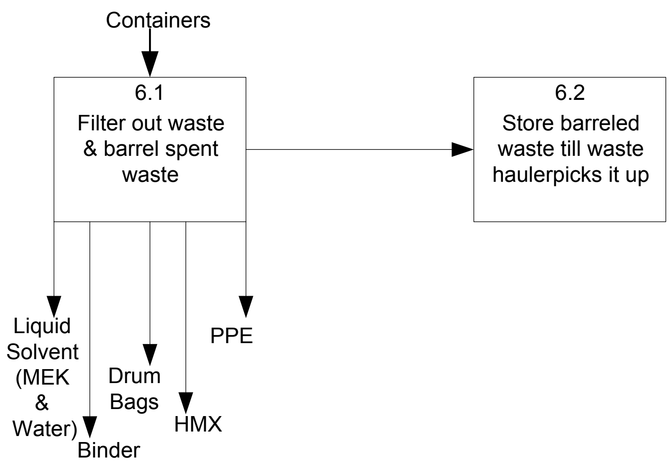

Figure 4. Ancillary Operation for Work Step 6.0

Rank Ordering of Opportunities

To deal with the numerous opportunities for pollution prevention in the process maps, the team determined the cost factors associated with the various waste streams. Attention was paid to the activity-based costs of managing each waste stream. Traditionally, direct costs were estimated by material purchase and possibly disposal fees while indirect cost were lumped together as overhead costs. Activity-based costing separates the overhead cost by estimating ALL the activities that occur while creating a product. The team assessed the cost of each waste stream by raw material purchase, time/labor, training, utilities/space, and regulatory fees. These costs are outlined in Figure 5. The waste streams include liquid solvent waste, PPE, binder, energy, drum bags, and HMX. The team estimated costs for each waste stream and determined what work steps generate the waste stream. For example, liquid solvent waste is mostly found in work steps three and four. In Figure 6, a Pareto diagram clearly shows that the solvent-contaminated wastewater stream in work step No. 4 is the most costly waste in the process. This waste stream consists of MEK in water and results from the filtering and drying of PBX.

Categories	Total Costs	1 De-Wet HMX (energy)	2 Loading and Weighing (PPE, binder, drum bags, HMS, & MEK)	3 Distillation (Liquid Solvent)	4 Filtering & Drying (Liquid Solvent)	5 QA (Recycled product)	6 Storage (Space)
A)Raw Materials	$191,386	$31,898	$31,898	$31,898	$31,898	$31,898	$31,898
B) Time/Labor	$912,431	$136,865	$182,486	$228,108	$228,108	$45,622	$91,243
C) Training	$21,419	$3,570	$3,570	$3,570	$3,570	$3,570	$3,570
D) Regulatory	$244,088	$0	$0	$48,818	$195,270	$0	$0
E) Space/ Utilities	$72,000	$7,200	$7,200	$7,200	$7,200	$7,200	$36,000
F) Total by Activity	$1,441,323	$179,532	$225,154	$319,593	$466,045	$88,289	$162,710
Percent	100%	12%	16%	22%	32%	6%	11%

Figure 5. Estimating the True Cost for the Material Losses

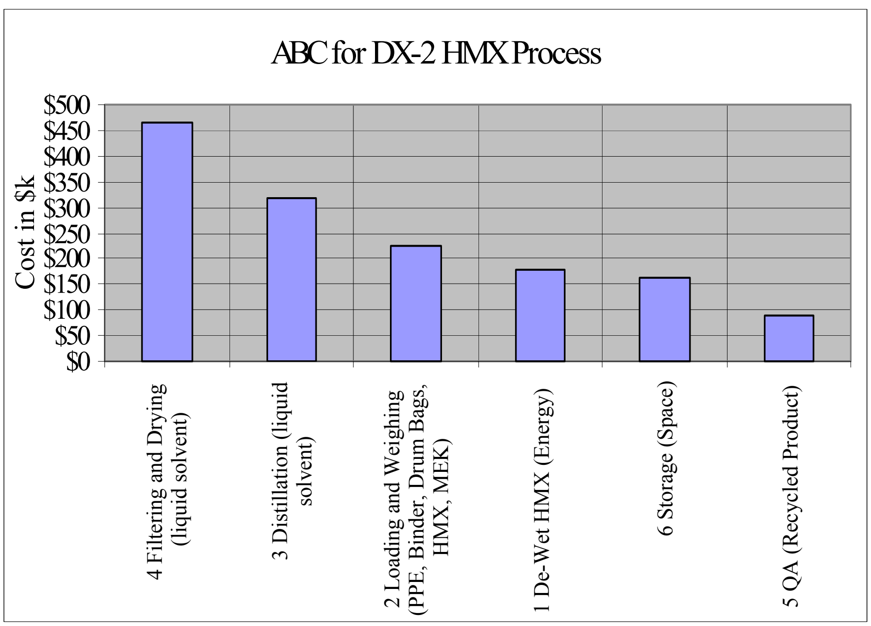

Figure 6. Rank Ordering the Material Losses

Root Cause Analysis

Using a fishbone diagram (Figure 7), the team examined the materials, process technology (machines), methods and people associated with the PBX slurry process to identify potential contributing causes of the MEK losses to the wastewater. Some of the more significant causes include the following:

- Need for a better extraction method;
- Inefficient condenser;
- Requirement for the use of MEK in the process; and
- Process is sensitive to operator’s actions so rework is often required.

The most significant causes are circled in the fishbone diagram.

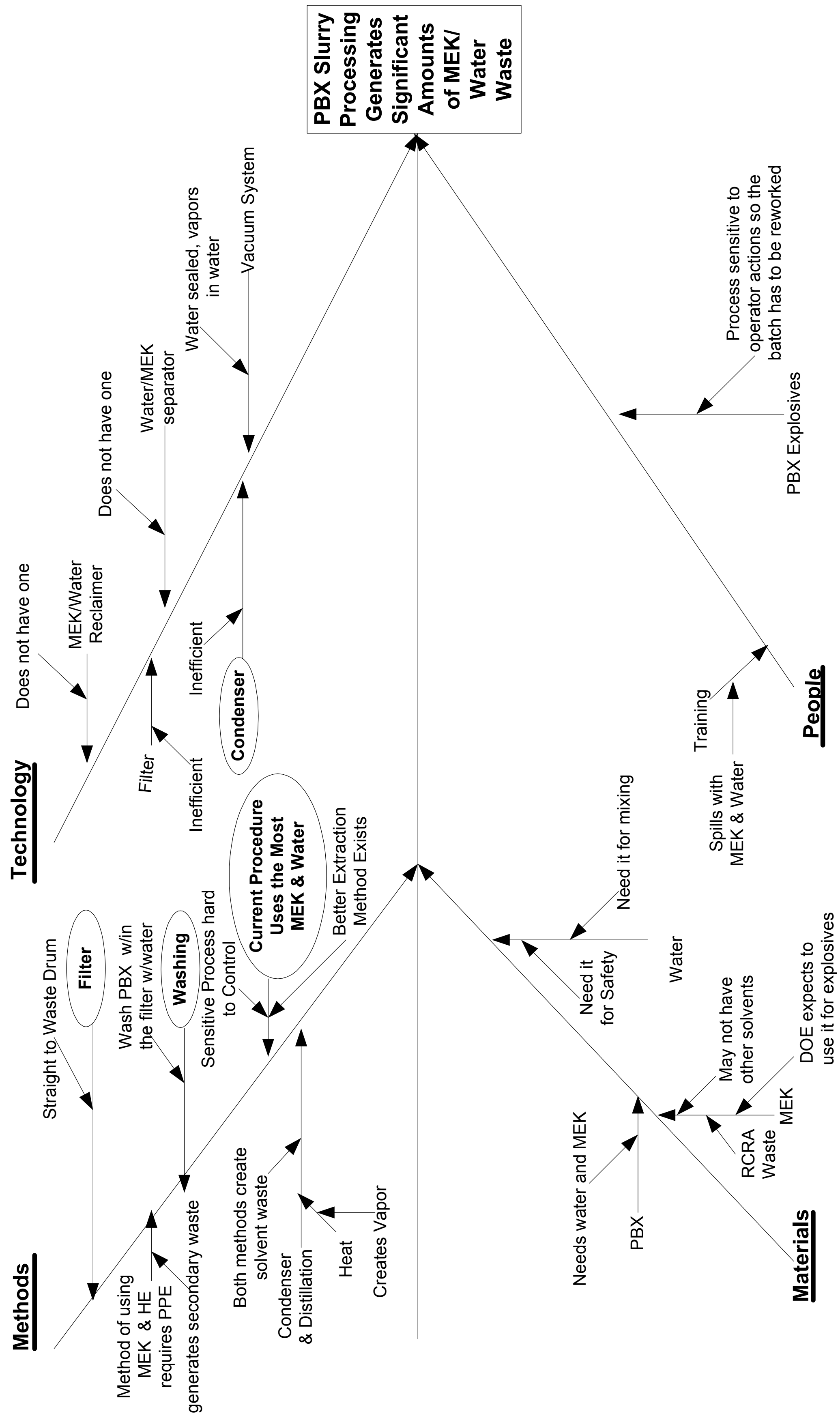

Figure 7. Root Cause Analyses

Statement of Problem

In order to reach a consensus understanding, the team prepared a statement of problem. It can be found in Figure 8.

To: Jim Stine
From: DX-2 PBX Team
Date: April 13, 1999
Re: MEK and Water Waste Concerns

The methods for making PBX explosives are creating a significant concern because we are generating large volumes of MEK and water waste. After our team examined materials, methods, machinery, and people that could affect the method for making PBX, we identified the following areas as primary contributors:

- Inefficient Filtering Procedure- goes straight to the waste drum.
- Inefficient Condenser- it does not do a good job of condensing and therefore contributes to the significant amount of MEK and water liquid waste.
- Excessive Washing- when washing PBX batch in the filter, we use significant amounts of water.
- Current Procedure- current procedure combines distillation and extraction and generates the most waste.

We feel that the problem results in avoidable inefficiencies that can eliminated or mitigates by reconfiguring the methods for making PBX. We request approval to continue further study of the problem to come up with a potential solution to address the issues identified above.

Figure 8. Building Consensus on the Problem

Generating Process Alternatives

The team used a brainwriting tool to develop a listing of 13 potential alternatives for addressing the solvent-contaminated wastewater. They are as follows:

1. Use a separator that would separate the water from the solvent;
2. Have a generator treatment process that would clean the water (to meet SWSC WAC);
3. Recycle MEK for cleaning purposes – reclaimed MEK may be used to clean at other sites
4. Reuse of solvent water (closed loop system – Pantex has already done this);
5. When making the PBX batch, stick to one efficient procedure (such as the Pantex Extraction Method) and make sure employees understand the new procedure;
6. Use less MEK at the beginning of the process;
7. When washing PBX batch in the filter, use little or no water;
8. Use a different lower mixer blade;
9. Use a more efficient condenser (this would give you more MEK and less wastewater);
10. Use a different and more efficient vacuum system;
11. Don't make PBX explosives at DX-2;
12. Give a free trip for any employee that comes up with a solution to reduce MEK and wastewater; and
13. Hire a consultant to do a walk through with DX-2 and recommend other P2 alternatives (may know environmentally-sound alternatives that other explosive areas are implementing).

Selecting an Alternative

Members of the DX-2 team used a bubble-up/bubble-down tool to prioritize the alternatives. The team did not eliminate any alternatives, but they did combine some of them. Figure 9 shows the priority order using criteria of effectiveness, ability to implement, and cost.

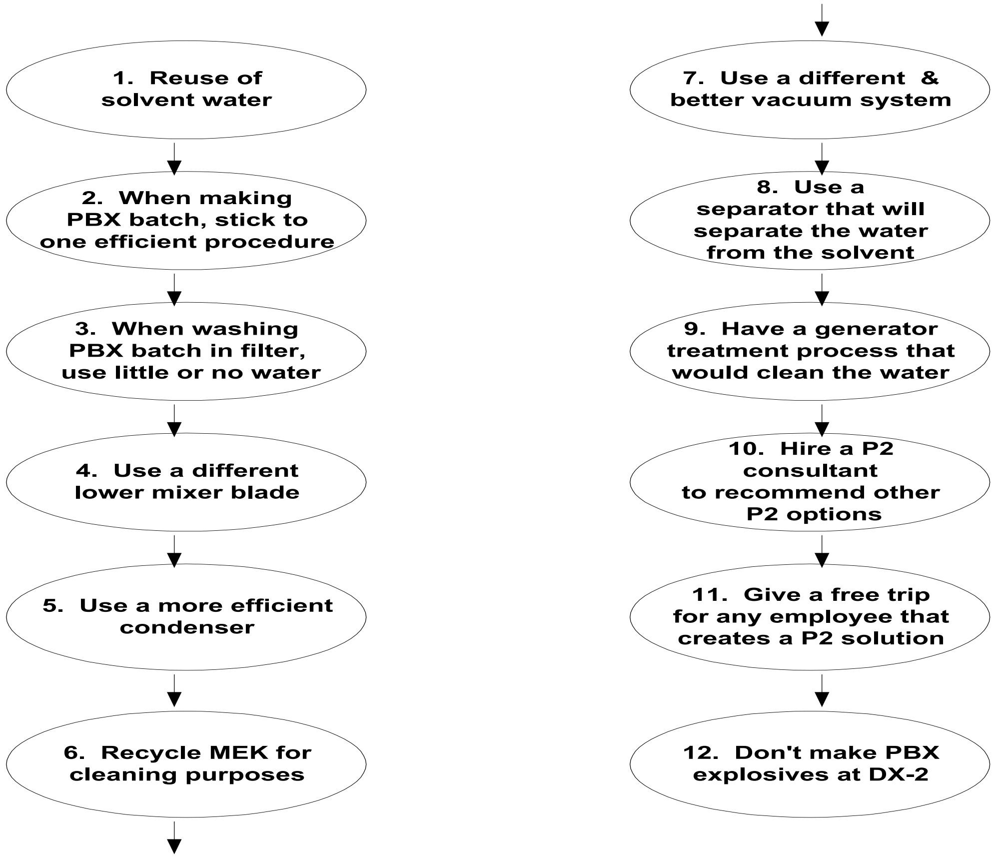

Figure 9. Prioritizing the Alternatives to Determine Optimal Solution

Implementing the Alternative

An action plan was prepared by the team to implement the alternative that they selected. This action plan is shown in Figure 10. Implementation needs to be coordinated through the Integrated Safety Management (ISM) program at the Laboratory. The team will meet on a quarterly basis to audit implementation progress and to quantify the metrics specified in the action plan. At the end of the first year, the action plan should be audited by an independent person to help the team determine what has been learned during the implementation and how that learning can be incorporated into the second year of the plan.

Action	Responsible Person	Performance Standard	Monitoring Technique	Completion Deadline	Resources Needed
Research other procedures (Particularly Pantex)	Ray Flesner, John Kramer, and Jim Stine	Monthly Meetings with Pantex	Keep minutes, track progress in quality assurance by seeking improvements in the process.	FY 1999 and beyond	Computer, paper, flip charts, and people
Draw up Construction Plans	John Kramer	Complete construction plans in FY 2000.	Monitor the percent completion.	FY 1999 and beyond	Paper, labor, new equipment, construction materials, etc.
Design improved condenser system.	John Kramer	Order improved condenser	Ensure that a condenser purchased would not have the same undesirable waste that the vacuum pumps generate.	FY 1999	New condenser
Test H-plastic to ensure it will meet production specifications	John Kramer, Ray Flesner, and Jim Stine	Elimination of batches not meeting product specifications	Testing small batches to avoid the use of inappropriate reactants.	FY 1999 and beyond	People, plastic, and training
Train affected personnel in pollution prevention techniques for current operations	Ray Flesner, John Kramer, Jim Stine	Training in each aspect of current operation	Training completed for each work step.	FY 1999 and beyond	Training manuals and people.

Figure 10. Action Plan for A More Efficient PBX Slurry Procedure

For additional Information about the compactor study or the Green Zia Program at LANL, please contact Tom Starke with the LANL Environmental Stewardship Office.

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